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Article

The Pattern and Process of Adoption and Scaling up: Variation in Project Outcome Reveals the Importance of Multilevel Collaboration in Agroforestry Development

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Abstract: Agroforestry is considered a subsistence system that balances the urgent need for food and income of small scale farmers with restoration and conservation of ecosystem services, and climate change adaptation and mitigation. The Vi Agroforestry Program aims to implement agroforestry as a means to alleviate poverty and increase resilience among the poorest smallholders. After seven years, the Vi Agroforestry Project in the Mara Region of Tanzania had an inter-village variation in the proportion of households with tangible surviving agroforestry trees ranging from 10%–90%. Using a multiple methods approach, this variation was analysed in relation to changes and differences among administrative districts and project zones regarding perceived barriers to agroforestry adoption, project interventions, governance and the chronology of the process. In districts and zones where collaboration among the project staff, government counterparts and other stakeholders had been established at multiple levels, more agroforestry trees survived and a larger proportion of households practiced agroforestry. The established collaboration made it possible to discover and consider opportunities and barriers to agroforestry development such as diverse stakeholder interests and perceptions. As a result, potential conflicts could be avoided and socially robust solutions developed, adapted and integrated into the local subsistence systems.

Keywords: dissemination of agroforestry; adaptation; technology adoption; poverty alleviation; collaboration; social learning; sustainable development; farming system; participant observation

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1. Introduction

Scaling up the establishment of trees and forest on degraded land and forests, as well as integrating with agriculture on arable land has received renewed attention with the increasing concern for global warming and climate change [1–4].

Agroforestry is considered a subsistence system that balances the urgent need for food and income of small scale farmers with the need to restore and conserve ecosystem services. In addition, agroforestry holds a genuine potential to contribute to climate adaptation and mitigation [3–10]. Nair [4] argues that trading of the sequestered carbon could be an additional opportunity for economic benefit to agroforestry practitioners, who are mostly resource-poor farmers in developing countries.

Considerable research and development efforts in the past have encouraged agroforestry practices demonstrating the relationship between agroforestry and improved livelihoods of small scale farmers [5–7,10–14]. However, scaling up of agroforestry has often proved difficult and a variety of reasons has been suggested. Sanchez [15] proposed that the perceived poor return and elevated labour investment of alley cropping is one reason for the poor adoption. Franzel *et al*. [11] argue that agroforestry technology is knowledge intensive compared to agricultural interventions like “Green Revolution Technologies” making the dissemination and adoption processes difficult. Pollini [16] argue that agroforestry has been designed with too much focus on biophysical process and to find the “perfect technology” with inadequate consideration of the socio-cultural realm.

Many projects and scientific studies are designed to consider and analyse few other than biophysical factors. Issues widely recognized to be critical to adoption of agroforestry, such as risk and uncertainty, the impact of labour, and market or tenure policies, were rarely investigated [17,18]. Similarly, Ajayi *et al*. [19] has argued that the explanation to the contradicting results of some agroforestry adoption studies lays in the institutional and social context. Mainly based on adoption studies of improved tree fallow, Kiptot *et al*. [20] have argued for the need to consider households in different stages of adoption, e.g., testers/experimenters, re-adopters, pseudo-adopters and adopters as motives differ during these stages.

Horizontal scaling up is the spread across geographical areas and to more people, while vertical scaling up is institutional in nature, involving different types of organizations and stakeholders from local to regional, national and international levels. This includes civil, public and business sector stakeholders such as grass root farmer groups, extension services, policy makers, private companies, and national and international organizations [21]. In order to achieve sustainable impact and to improve adaptive capacity, horizontal and vertical scaling up have to be linked [21–23]. Likewise, Long and Long [24] and Long [25], stress the importance of interactions between people, technologies and institutions. Sanginga *et al*. [26] emphasize collaboration as a way to improve coordination of the activities among different stakeholders. Similarly, Daniels and Walker [27] argued for the importance of developing collaborative learning processes among stakeholders in complex natural resource management situations.

The majority of agroforestry-adoption studies have been based on formal household/farm surveys comparing the characteristics of non-adopters with that of adopters [18,20,28,29]. Mercer [29] identified village-level studies and spatial analysis of adoption as an important area for future research.

The Vi Agroforestry Program (Vi AF) has worked with and promoted tree planting and agroforestry development among small scale farmers since the mid 1980s [30–38]. After seven years in operation, the Vi Agroforestry project in the Mara region in Tanzania (ViAFP) had an inter-village variation in tangible surviving agroforestry trees ranging from 10%–90%. Johansson *et al*. [32] pointed out that for a more comprehensive understanding, it is necessary to make a deeper analysis of the wider socio-cultural context of the project and the scaling up process itself considering differences in governance at multiple levels. The aim of this study was to improve the understanding of the pattern and processes of agroforestry adoption and scaling up. We used a multiple method approach to study differences and changes among administrative districts and project zones in relation to perceived barriers to agroforestry adoption, project interventions, governance, household's perceptions related to agroforestry and the chronology of the process. Our hypothesis was that important explanations to inter-village variation in agroforestry adoption could be found in the development process itself and differences in the socio-cultural context as well as governance in districts and zones.

2. Background

2.1. The Vi Agroforestry Program

The Vi Agroforestry (ViAF) is a development cooperation and Non Government Organisation (NGO) with its headquarter in Stockholm, Sweden. Presently, ViAF reaches over one million people with training and advice through seven projects in the Lake Victoria basin. ViAF's projects are funded mainly by collections from the public and grants from the Swedish International Development Cooperation Agency (Sida). ViAF started in 1983 by the Swedish magazine "Vi" (English: We), the voice of the consumer cooperative movement, as a tree planting project in Kenya. Subsequent projects were started in Uganda in 1992, in Tanzania in 1995 and 1999, and in Rwanda in 2004 [33–38].

2.2. The Mara Region

The Tanzanian part of the Lake Victoria basin covers an area of 84,920 km^2, or 46% of the lake catchment area, and includes the Mwanza, Mara, Kagera and Shinyanga regions. Each region is organised in districts, divisions, wards, and villages. On average, there were 667 people per km^2 of arable land in the Mara region (estimate for year 2000), *i.e.*, 0.14 ha of cultivated land per person. At the time of the field work for this study, the Mara region had five districts: Tarime, Musoma, Musoma rural, Bunda and Serengeti, and thus these names are used in this study. Later, a sixth district, Rorya, was added. The lake zone, including the project area of Vi AF project, is a strip of land about 10–15 km wide along the lake (Figure 1) including parts of Tarime, Musoma rural and Bunda districts with an altitude from 1100–1200 m.a.s.l. The main livelihoods in the lake zone include subsistence agriculture dominated by crop production, fishing and livestock keeping.

Figure 1. Location of the Mara region Vi Agroforestry Program (AF) project area.

According to official government reports (1998), people in the lake zone faced several problems including high and increasing pressure on arable land, low and unpredictable agricultural production due to erratic rainfall, increasing poverty coupled with malnutrition, high incidences of disease and rapid environmental degradation. The situation in Mara region and particularly the Lake zone is still critical. Annual precipitation is normally less than 900 mm and is bimodal, with two main rainy seasons, from about mid-September to December and from February to May. The start and duration of the rainy season are highly variable causing difficulties in predicting the timing of farm operations. This situation for agricultural practices is further aggravated by commonly occurring mid-season (January to February) dry spells. Soils in the lake zone are mainly sandy, easily exhausted with poor water holding capacity and susceptible to erosion. There are also some pockets of heavy clay soils that become seasonally waterlogged. In addition to the lake zone, the Mara region includes the midland zone and the Tarime highlands. Eleven ethnic groups are represented in the lake zone with the Jita, Luo and Kuria being the largest. Jita and Luo are semi-agropastoralist and Kuria are agro-pastoralists [39–41].

2.3. The Vi Agroforestry Project in the Mara Region

The ViAF registered a local NGO to operate their Mara region Vi Agroforestry Project (Vi-AFP). In 1994, the project appraisal was carried out and field activities started with the first project extension agents (PEA) employed in the beginning of 1995. The 80% food insecure, small scale farming households of the Lake zone of Mara Region was the target group of the project. The project's development objective was to make a substantial improvement in the livelihood of this group through improved food and nutritional security, increased fuel wood availability, and increased sources of income. The project implementation approach used was first labeled; "age and gender sensitive participatory agroforestry extension". From 1999, this approach gradually developed to include a close collaboration with government district extension and local leaders.

The number of project extension agents (PEA) increased from 16 in 1995 to 113 in 2000. The project had a total number of 155 permanent employees in December 2000. Each PEA was responsible for a specific area including about 300 households (area of concentration). These areas were established in 104 villages along the lake in Tarime, Musoma and Bunda Districts. The rural project area was divided into seven subprojects called zones (shown in the map of Figure 1) with about 15–16 areas of concentration in each. With a few exceptions, all villages in a zone were located in the same division. A zonal manager was responsible for the running operations in each zone. The total number of households in the project area in 2001 was about 34,500.

In an effort to focus on the most useful agroforestry interventions for the small scale farmers, a consolidated package gradually developed in collaboration with farmers, district staff, and ICRAF-Shinyanga (International Centre for Research on Agroforestry, today World of Agroforestry Centre, field station in Shinyanga). The aim was to plant all trees in a way that improved and protected the soil and conserved the water resource. As their common aim was to improve productivity and sustainability of the local farming system the project, government extension services and ICRAF-Shinyanga joined efforts. The collaboration focused on the integration of sustainable practices in the local subsistence systems of Mara, including agroforestry, improved crop varieties, organic farming, and soil and water conservation. An important part of the collaboration was farmers co-designed learning experiments. In the year 2000, 54 tree species and four improved crop varieties were promoted by the project [32,35,36,39,42].

3. Method

The point of departure for this study was previous studies stressing the importance of the socio-cultural context and governance system in agroforestry development and the development process itself [16,17,19–26,32]. Apart from the differences revealed among villages influencing agroforestry adoption in Johansson *et al*. [32], the study pointed out the need to further study the socio-cultural and governance differences at multiple levels and the dynamics of the scaling up process itself [32]. Hence, the aim of this study was to deepen the understanding of how this pattern and process influence agroforestry adoption. To do this, we used the hypothesis that important explanations to inter-village variation in agroforestry adoption could be found in the development process itself, the differences in the socio-cultural context, and the system of governance among districts and zones.

To reach this aim and test the hypothesis, a multiple method approach was used. First, a single ANOVA analysis was conducted to test if the differences among administrative districts and project zones were significantly separated in terms of the dependent variables (Appendix I) used in Johansson *et al*. [32]. Secondly, district and zonal means were calculated for the dependent and independent variables. Tukey's test was used for pair-wise comparisons to determine if these means were significantly separated between the different levels of districts and project zones. Thirdly, fitted line-plots were used with the district or project zone as a categorical variable to determine if the influence of the independent variables (presented in Table 1 and Appendix II) used in Johansson *et al*. [32] on project outcome (the five dependent variables) was neutral, positive or negative among the different levels of districts and zones.

Table 1. Factors considered in five social and ecological subsystems of adoption represented by 26 variables (adopted from Johansson *et al*. [32]).

Subsystems of adoption		Factor	Variables
i	Local governance	Local governance related to agroforestry development	Local collaboration, administrative district and project zone
ii	Local belief	Perceptions related to trees and agroforestry	Perceived labour requirement of tree establishment, perception of tree ownership and the benefits of agroforestry trees
iii	Physical environment	Characteristics of soil and water	Main soil type, water sources and distance to the lake
iv	Subsistence system	Subsistence activities and practices affecting agroforestry establishment	Main economic activity, tilling method and main crop
v	Project	Project interventions	Level, duration and type of project activities and characteristics of the project extension agent

Finally, we did a qualitative analysis of data collected using participatory observations and official and internal project documents ranging from meeting protocols, project accounts, notes and documented discussions among project staff and project partners. Our analysis included the following iterative steps; (1) reading of the data material; (2) structuring of the dataset and writing;

(3) discussions about what was written including descriptive models of the chronology of change considering differences among districts and zones; (4) discussions and reflections on the text and the models; (5) to confirm and validate the qualitative analyses comparing with quantitative results; (6) trying to falsify our findings using the same dataset; (7) relate the results with similar scholarly work. Then, we went back through the steps several more times to assure that all our findings were well grounded in the data [43].

Collaboration was assessed in terms of regular or occasional interaction and whether the interest to collaborate was one-way or two-way, giving four levels: (i) occasional interaction with one-way interest to collaborate; (ii) occasional interaction with two-way interest to collaborate; (iii) regular interaction with one-way efforts to collaborate; (iv) regular interaction with two-way efforts to collaborate.

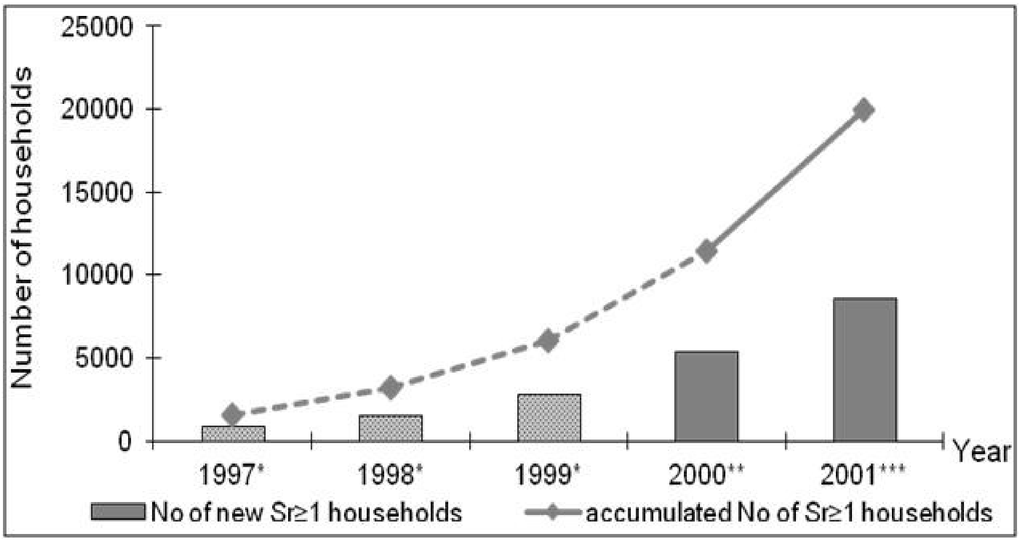
The author group includes representatives from different levels and sectors of the project and the scaling up process, e.g., the program (international NGO), project (local NGO), local government institutions (Regional and District Agricultural Office) and adaptive research (international research NGO). This multiple method approach enables us to better consider the socio-cultural realm and the governance context within which the adoption of agroforestry takes place stressed in a number of agroforestry adoption studies (e.g., [11,16,18–20,29]). Similar multiple-method approaches have proved useful in other research fields, e.g., health sector [44,45], recreation [46] and in inter-sector studies of health and horticulture research [47].

4. Result and Discussion

4.1. A Chronological Account of the Scaling Up-Process

After a slow and struggling start from 1994, the scaling up process started to gain momentum in 1999. From about 5000 households in 1999, the total number of households with surviving agroforestry trees reached close to 20,000 in 2001 (Figure 2). Farmers' perceptions of the benefits of agroforestry and its influence on agricultural crops and soil were highly variable in the project area. Households believed in general that all tree species have a negative influence on the crops if planted in or nearby agricultural fields. Gradually it was realized that this perception was also reinforced through a message extended to the households by the government agricultural extension agents (Figure 3). Farmers were told not to plant trees in the crop fields as trees were perceived as interfering with crops. The agricultural extension agents even denied farmers seeds of improved crop varieties if they planted trees. This incompatible message of the project and government extension agents was recognized and understood in the beginning of 1998. With improved collaboration and joint training of government and project extension agents (Figure 3), the conflict gradually diminished. As a result, farmers' experience of the benefits and their perception of the influence of agroforestry trees on crops progressively improved. In 2001, it was found that, on average, close to 37% of the 34,500 households in the project area believed that agroforestry trees had some reasonably good effect on the crop and/or soil. Musoma rural district and Suguti zone had the highest proportion of households believing in the good effect of agroforestry.

Figure 2. Progress of scaling up in terms of total number of households with surviving agroforestry trees (Sr ≥ 1), out of the 34,500 households in the project area. The histogram indicates the additional number of households with surviving trees each year. Dotted lines and light grey columns are based on reports from the project extension agents.



* data from VEA reports; ** data from participatory performance assessment in August–September 2000; Hh with surviving trees/soil improvers planted during the short rains in the end of 1999/beginning of 2000 (275 mm rainfall) and the long rains lasting from March to end of April 2000, (340 mm rainfall);*** data collected for this study in May 2001.

In 1997, collaboration and involvement of local stakeholders was limited to occasional meetings with the regional and district forest offices (Figures 3 and 4). Agreements were established with the village leadership in each new village included in the project. As the relationship between village leadership, the households and the PEA was identified as one important condition to improve project outcome strategies and efforts were designed to develop local collaboration (Table 2). Collaboration gradually improved but the rate of improvement differed depending on area. The interest and intensity of collaboration between different local government functions (executive, technical and political) in support of the project efforts varied depending on the district, division/project zone, ward and village (see Figures 3–6). After the election in October 2000, and the resulting change of the politically appointed leadership at village to district levels, relationships that had previously not developed as planned improved. Not only did the relationship between the project and government leaders and staff improve, it was also perceived among project staff and households that these changes improved collaboration in general and particularly between households and the village leadership.

In mid 1998, the project management realized that a majority of households in the project area were unsure that they were the legal owners of the trees they plant on their land and thus they were not sure they would be allowed to harvest the trees they plant (Figure 3). This belief was found to be rooted in a government policy, the Forests Reserved Trees Order [48], restricting the cutting of certain high quality timber species. This policy had been enforced by the forest service mainly in the woodland savannahs (Miombo) forest areas of Tanzania. The issue was raised with the regional commissioner and ways to handle it discussed.

Figure 3. Changes and chronology of perceived barrier, project intervention, development of governance and change in households' perception.

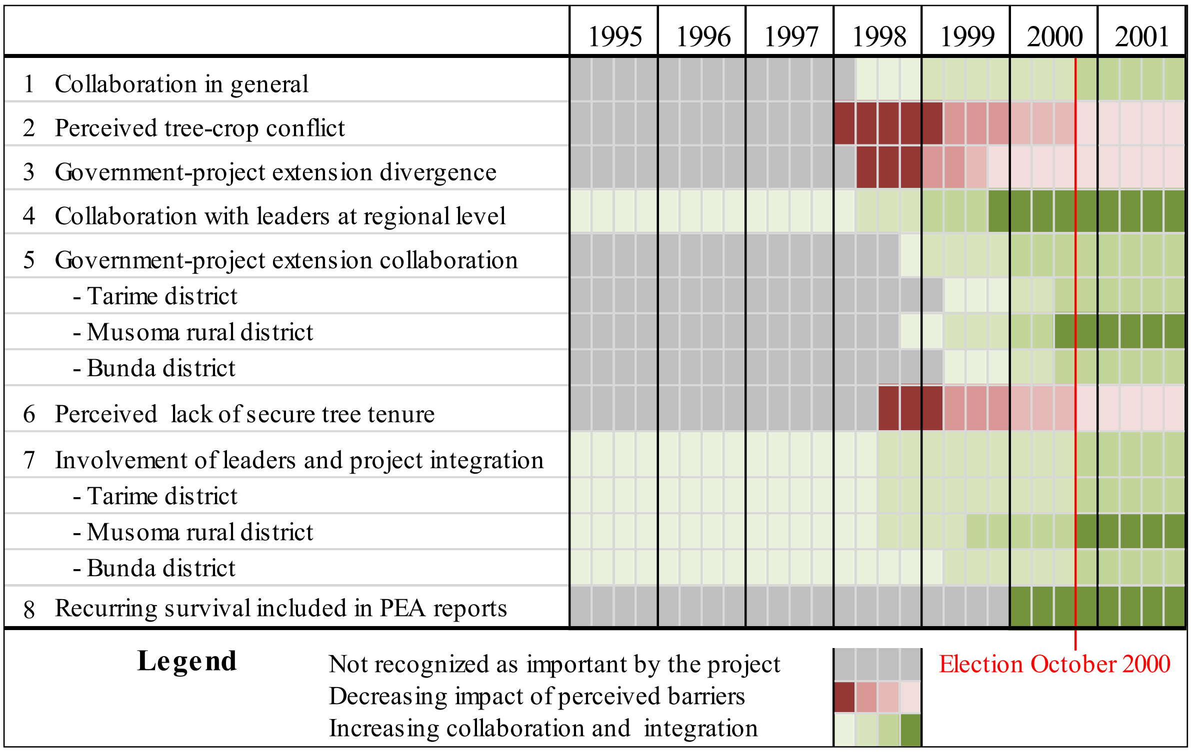


Figure 4. Illustration of project interaction and collaboration with local government institutions from region to village levels at the end of 1997. The colors blue, green and red represent the executive, technical and political sections of the local government administration, respectively. The vertical red line between government and project extension agent indicate the conflict between them.

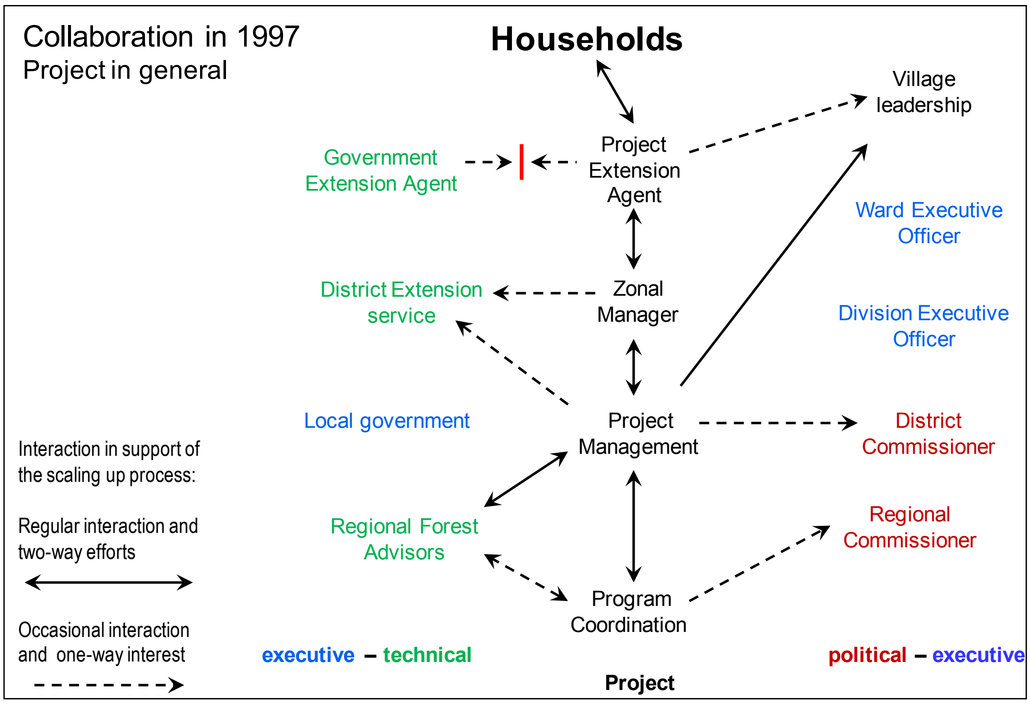


Table 2. The main components and developments of the project implementation strategy and process, with comments on implementation.

Component	Implementation
A decentralised organisation: Zones were established as sub-projects with zonal mangers (ZM) developing zonal work plan (WP) together with the project extension agents (PEA).	Zonal managers appointed in 1997, zonal WP developed in end of 1998
Concentration: PEAs work in well-defined areas with not more than 350 households, *i.e.*, Area of Concentration (AoC).	Implemented from mid 1998
Regular capacity building of project staff: Monthly workshops conducted for ZM's and bursh-up workshops for PEA's with focus on the most urgent needs according to season, identified by the ZMs and PEAs themselves.	Started in end of 1998
Action planning in groups at sub-village level (GAP). Workshops were conducted in small corporate groups of households to evaluate previous seasons work, put up targets for the coming season and make plans to reach the set targets.	Started in 2000; 13,000 Hhs had been engaged in GAP-groups/exercises up to May 2001
Joint training with district agricultural office involving both agricultural extension agent (AEA) and PEA.	Courses six times/year starting with Musoma district from mid 1999
Step-wise building of household capacity: Households capacity to be considered when advising farmer on quantities and interventions taking the households a step at a time towards a well-integrated and increasingly comprehensive farming system.	Started in the beginning of 2000
Partnership with local leaders: Local leaders participate in organising meetings and training events, distribution of seeds and follow-up of field activities.	Implemented from 1999—practiced in 50% of villages in mid 2001
Adaptive action research and extension: To involve farmers, agricultural extension, ICRAF, other NGOs and Lake Zone Agriculture Research and Development Institute in adaptive action research to develop and integrate sustainable interventions in collaboration.	Started in 1999: 420 Hh in 40 villages involved in research collaboration at the end of 2000
Action oriented learning: To improve the capacity of PEAs and households to participate in action oriented and self-discovery learning (LePSa).	Started in 1998; 2 × 2 week LePSa course for PEA
Employee performance appraisal (EPA) based on implementation assessment -PEAs committed themselves in consensus with the ZM to targets for the coming two seasons while the project took on commitment for training and meetings requested by the PEA.	The first EPA was conducted in the end of 2000

This resulted in assistance mainly from the region and districts. In the beginning of 1999, the regional and district commissioners started to inform farmers in public meetings that whatever tree species they planted on their own land will be their property. This gradually became the message of most actors involved with the farmers but the perception of ownership still varied in 2001 from one district and zone to another (Figure 3). Hence, the success to change this perception also varied. In 2001, it was found that approximately 60% of the 34,500 households in the project area believed they would be allowed to harvest the trees they plant. Two thirds of the households in the Suguti zone believed that they own the trees they planted, which is the highest proportion among all zones. This could not have been accomplished without the involvement of higher authority and agreement among stakeholders.

Figure 5. Illustration of project interaction and collaboration in Tarime and Bunda districts with different local government institutions from region to village levels in mid 2001. For further explanation see Figure 4.

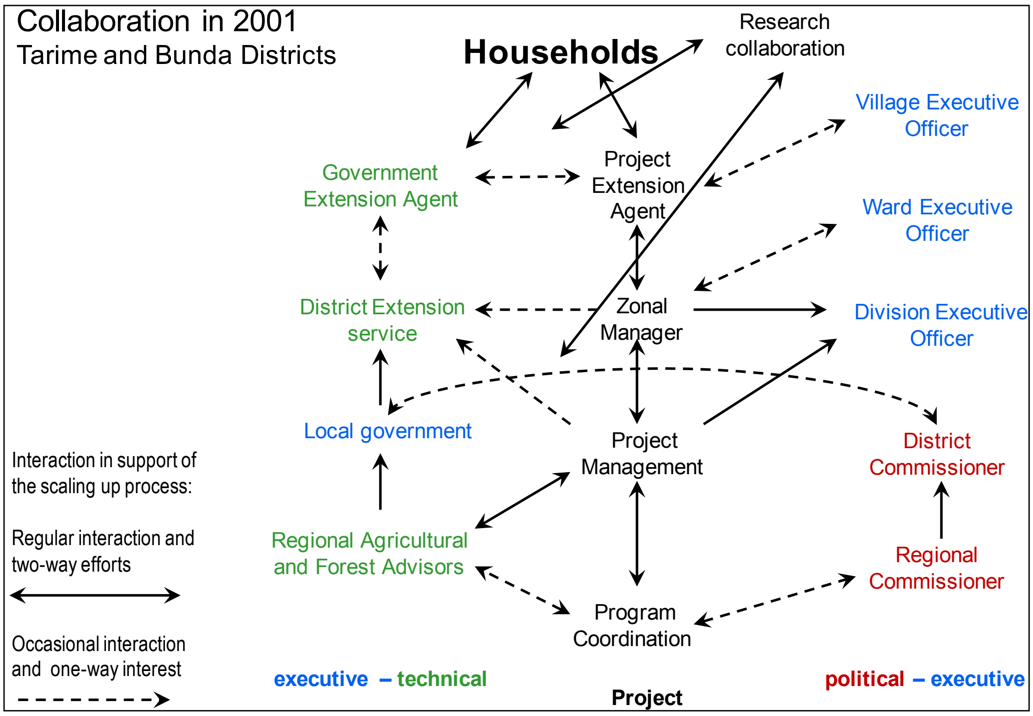
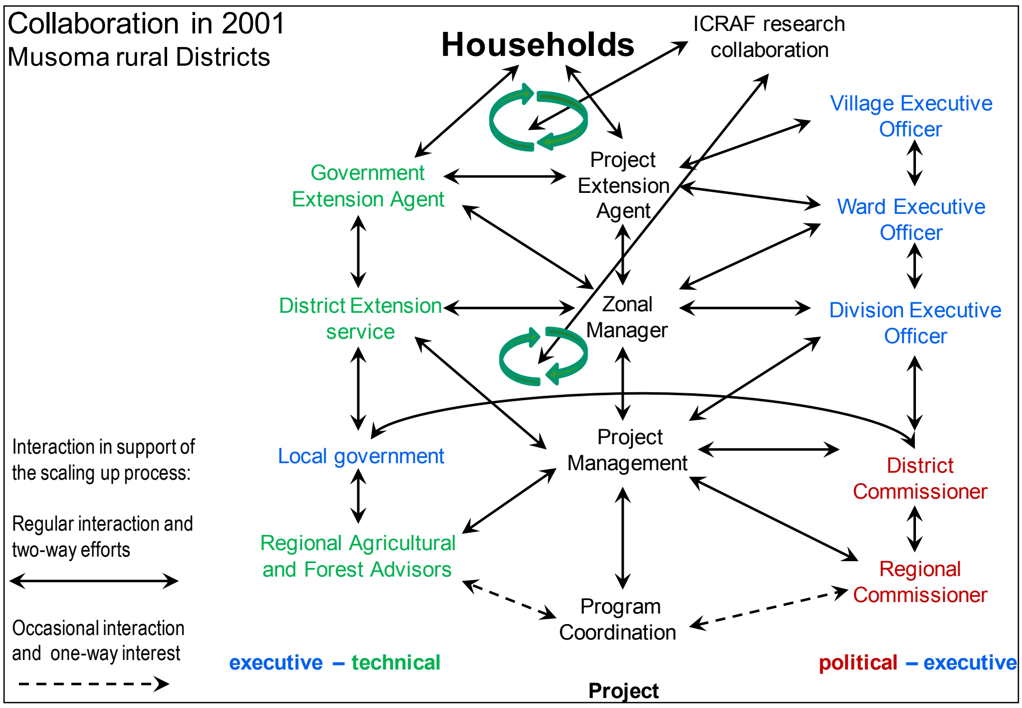


Figure 6. Illustration of project interaction and collaboration in the Musoma rural district with different local government institutions from region to village levels in mid 2001. For further explanation see Figure 4.



Another obstacle to a regular tree planting commitment was the general belief that trees are planted once and these trees must mature and be harvested before trees can be planted again. Furthermore, the reporting system of the project had a focus on the number of households with surviving trees. This gave no incentive for PEA to go back and build motivation for tree planting among farmers that already had surviving trees. This problem was realized quite late and a change in the reporting format providing for the number of households with surviving trees during multiple seasons was included in the beginning of year 2000. Gradually, with the awareness of these problems, the project strategy was amended (Table 2). From a focus on technical training of tree establishment during the first 3–4 years, the in-service training gradually changed, to build the PEAs' capacity to empower the households and to build collaboration and partnership between leaders, extension service and households.

PEAs were trained in the LePSA approach (Learner-centred, Problem-posing, Self-discovery and Action-oriented) [49] as part of this strategy (Table 2). This training started in mid 1998 and was carried out as the two last steps (two weeks each) of an eight-week training program for the PEA to complement the previously more technically oriented training. As a result of this training and other project efforts (Table 2), collaboration and integration of the project into local structures improved considerably from 1999, particularly in the Musoma rural district (Figures 3–6).

To facilitate learning, project activities were integrated with adaptive research done mainly by ICRAF and to some extent by the Lake Zone Agricultural Research and Development Institute (LZARDI). Farmers were encouraged to bring up tasks that where collaboratively addressed and solutions developed among farmers, project staff, researchers and agricultural staff. In the end of the year 2000, the number of farmers involved in research collaboration reached 420, distributed in 40 villages [42] (Figure 6, top).

A stakeholder workshop was conducted in Tarime on 24–25 April 2001 involving farmer representatives, all NGO and government organizations active in the agricultural sector of the Mara region, ICRAF Shinjanga, and the LZARDI. A common platform for collaboration was initiated at the regional level for integrated soil fertility management, a subject agreed to be applicable to all stakeholders' work. The platform was expected to harmonize and integrate plans, activities and messages from different stakeholders in the region. It was further agreed that the ICRAF-ViAFP research farmers together with the LZARDI farmers should form a common ground on which sustainable practices could jointly be developed and integrated into the local farming systems (Figure 6).

The integration and cooperation between government and project structures and its development is illustrated in Figures 4–6. The ViAF-Program coordinator participated in meetings at interregional and national levels concerning development efforts of the Lake Victoria basin. Project managers and sometimes the program coordinator participated in meetings with the Mara regional administration. Project headquarter staff and zonal managers participated in regular district management meetings to integrate project plans with district government plans and to coordinate project extension messages and training with those of the government agricultural extension. Training of the project extension agents was increasingly carried out jointly with training of government agricultural extension agents. The joint training session were shared by the project and government extension every second month. As the administrative divisions were about the same as project zones, division executive officers and ward executive officers participated in quarterly project meetings arranged at division level including all PEAs in the division, the project zonal manager and staff from the project HQ. Ward executive officers, village leaders and sub-village leaders were involved in project activities, like awareness creation, training events, seed distribution, village meetings and follow up of project activities. However, as mentioned above, the intensity of interactions and interest to collaborate varied among district (Figures 5 and 6). In 2001, regular collaboration with multiple interests had developed in Musoma rural district from village to district levels while in Bunda and Tarime districts, collaboration was more dependent on project initiatives and support (Figures 3–6).

4.2. Local Governance and Belief System

Using single ANOVA analyses of the dependent variables against the district and the zone, we found that the differences among districts and among project zones were significant (p-value<0.050) in terms of all dependent variables used except for the proportion of households with few surviving trees (Table 3). Hence, the situation in the district and project zone in which the villages were situated was clearly important for the household's decision to continue to establish and integrate trees on their farm.

Table 3. Level of significant influence of district and project zone tested with single ANOVA against five dependent variables (Table 1).

Area	% Households with 1–30 surviving trees	% Households with 40 or more surviving trees	% Households with 5 or more surviving species	Total no. of surviving trees divided by all households	Total no. of seasons from which trees had survived
Administrative district	ns	0.013	0.015	0.012	0.010
Project zone	ns	0.006	0.011	0.005	0.017

The villages in Musoma rural district had in general a larger proportion of households practising agroforestry and more surviving trees per household compared to the other two districts (Table 4, the last four columns). In the Musoma rural district, farmers also had to a larger extent adopted tree planting into the seasonal farming calendar (Table 4, the last column).

Suguti zone had the largest proportion of households practising agroforestry and with more surviving trees per households compared to the other zones (Table 4). The Majita zone had the highest proportion of households with few surviving trees, which was expected as it was the newest project zone. Majita zone had in general a project outcome across the five significant responses similar to that of the zones in Tarime and Bunda districts (Table 4). At the time when the Majita zone was established in 1999–2000, collaboration in the Musoma rural district was already well developed. Appropriate examples of good agroforestry farmers were readily available in the neighbouring zone of Suguti. Furthermore, one pilot village in Majita was operated through the Suguti zone one year in advance of the start up of the Majita zone.

Although local collaboration did not come out as an important factor explaining the inter-village variation in the project outcome, the most advanced performing district (Table 4) Musoma rural, located closest to the project headquarter, benefited from a well developed collaboration at all levels (compare Figures 5 and 6). Among the zones, collaboration in Kinesi and Suguti zones were perceived by the project advisors to be more developed compared to that in the other zones (Table 5, column one).

Table 4. Average project outcome in the three district and seven project zones across the five dependent variables, columns 2–6, (Appendix I) expressed in proportion of households (Hh) out of 34,500 (columns 1–4), number of trees per Hh (column 5) and total number of seasons from which trees have survived (column 6). Districts and zones with the same letter within the same column are not significantly separated (Tukey's test of pair wise differences). Upper case bold and lower case normal letters are used for districts and zones, respectively.

District/Zone	% of Hh with 1–30 and 40 surviving trees or more	% Hh with 1–30 surviving trees	% Hh with 40 or more surviving trees	% Hh with 5 or more surviving species	Average no. of surviving trees per Hh	Total no. of seasons from which trees have survived
Tarime	**50.7**	**28.8 A**	**21.9 AB**	**40.6 AB**	**35.1 AB**	**14.9 B**
1 Shirati	47.6	24.4 a	23.2 ab	36.2 ab	36 ab	13.3 b
2 Kinesi	54.3	34.1 a	20.2 b	46.0 ab	34 ab	15.9 ab
Musoma	**60.9**	**30.1 A**	**30.8 A**	**47.4 A**	**45.1 A**	**18.6 A**
3 Musoma	58.2	25.6 a	32.6 ab	48.0 ab	51 ab	19.5 ab
4 Suguti	65.4	27.6 a	37.8 a	53.6 a	55 a	20.1 a
5 Majita	58.3	38.1 a	20.2 b	38.9 ab	25 ab	16.0 ab
Bunda	**50.8**	**30.7 A**	**20.1 B**	**34.8 B**	**24.3 B**	**14.6 B**
6 Kenkombyo	47.0	27.4 a	19.6 ab	36.3 ab	26 ab	12.2 ab
7 Nansimo	53.0	32.6 a	20.4 b	34.0 b	23 b	15.9 ab
Project %	**54.1**	**29.9**	**24.3**	**40.9**	**34.8**	**16.0**

Table 5. District and zonal mean of variables related to local collaboration and key perception in the village (for further explanation, see Table 4).

District/Zone	Project advisors scoring from 1 to 5	% of households scoring the collaboration between PEA and village leaders to be good	% of households believing they own the trees they plant	% of households believing in the good effect of agroforestry
Tarime	**4.07 A**	**59.1 A**	**53.1 A**	**35.1 A**
1 Shirati	3.73 b	57.2 a	51.5 a	37.9 a
2 Kinesi	4.50 a	61.5 a	55.1 a	31.6 a
Musoma	**4.30 A**	**62.4 A**	**62.6 A**	**39.5 A**
3 Musoma	4.31 ab	64.1 a	60.7 a	38.5 a
4 Suguti	4.33 ab	64.8 a	67.3 a	44.5 a
5 Majita	4.25 ab	57.5 a	58.6 a	34.2 a
Bunda	**4.14 A**	**63.9 A**	**62.5 A**	**36.9 A**
6 Kenkombyo	4.12 ab	64.9 a	64.9 a	38.8 a
7 Nansimo	4.14 ab	63.3 a	61.1 a	35.8 a

In Johansson *et al*., households' perception of tree ownership (Table 5, column three) was one of the two most influential variables in the models explaining the variation in the village proportion of households with a tangible and long-term commitment to agroforestry, whereas it was not included in the model explaining the variation in households testing agroforestry [32]. Project outcome improved in general with an increasing proportion of households believing they owned the trees they planted (Appendix III, Figure A1). Among the districts, Musoma rural, and among the zones, Suguti had the largest proportion of households believing they owned the trees they plant (Table 5, column three).

Households' perception of the effect of agroforestry-trees planted in the cropland had the strongest effect in the model explaining the variation in the average number of trees per households [32]. In a plot, this effect appears marginal to positive depending on zone or district (Appendix III, Figure A2). Among the three districts, the proportion of households believing in the good effect of agroforestry trees was largest in Musoma rural and among the seven zones, Suguti had the largest proportion in this respect (Table 5, last column).

The strong influence of households' perceptions shows that households may carry views on interventions that have a clear impact on the adoption and scaling up process. These views are often not observable, difficult to learn about and thus hard to handle. When the numbers grew of households in a village with evidence of harvested trees and with a good effect on the crops, late adopters may have been convinced to start with tree planting and agroforestry due to this good result rather than as a direct consequence of project interventions or improved collaboration. However, when these adverse beliefs were first discovered in 1998 it was clearly an obstacle for the progress of adoption in almost all villages, an obstacle that decreased with increasing project efforts and agreement among stakeholders (Figure 3).

4.3. Physical Environment and Subsistence System

The sandy luseni soil dominated the villages in Musoma rural district whereas the more clay rich mbuga-soil was more common in Tarime district. At the zone level, Musoma and Majita zone were dominated by the sandy luseni soil. In Kinesi and Kenkombyo zones, mbuga soil was dominating with Shirati and Suguti zones being intermediate in this respect (Table 6, column one).

It is obvious from the data presented in Table 6 that co-variation also existed between soil type, main crop and main tilling method; manual tilling and cassava generally dominate in villages with sandy soil. At the district level, the district dominated with sandy soil, manual ridging and cassava appears to be the best performing district in terms of project outcome, *i.e.*, Musoma rural district (compare Tables 4 and 6) despite poor water holding capacity and easily eroded soils. At the zonal level, the Suguti zone with the highest proportion of agroforestry adoption has about half of its villages dominated with sandy soil, manual ridging and cassava whereas the other half are dominated with the clay rich mbuga soil, flat ploughing and cultivation of other crops besides cassava. Even though these variables influence the project outcome, this inconsistency between the district and zone levels indicates that there are other factors that also influenced project outcomes.

Table 6. Physical and farming system variations among districts and zones (for further explanation, see Table 4).

District/Zone	% of villages dominated with sandy soil	% of villages dominated by cassava	% of villages dominated by manual tilling
Tarime	**44 A**	**52 B**	**26 A**
1 Shirati	67 b	60 ab	47 b
2 Kinesi	17 c	42 bc	0 c
Musoma	**80 B**	**78 A**	**82 B**
3 Musoma	100 a	100 a	100 a
4 Suguti	47 bc	40 bc	53 b
5 Majita	100 a	100 a	100 a
Bunda	**64 AB**	**00 C**	**77 BC**
6 Kenkombyo	25 c	0 cd	100 a
7 Nansimo	86 ab	0 d	33 b

4.4. Project Interventions and Project Outcome

The most significant differences among districts and zones in terms of tree survival and agroforestry adoption as a result of the project were accomplished through field training workshops and farmer to farmer tours (Table 7). Correspondingly, the district and the zone with the largest proportion of agroforestry households and number of surviving trees, the Musoma rural district and the Suguti zone, had the highest number of conducted farmer to farmer tours (Table 4 and 7). Still the proportion of households in these two areas ranking the PEAs as very competent in agroforestry was among the smallest compared to that of the other districts and zones (Table 7, column three).

Table 7. District and zonal mean of variables related to the capacity and attributes of the project extension agent and project interventions in the village (for further explanation, see Table 4).

Districts/Zones	No. of training workshops per household	No. of farmers to farmer tours per household	% of Households ranking the PEA as best in agroforestry knowledge	Weeks of PEA's in-service training	Months of PEA's project employment	Months of project activities
Tarime	**0.66 B**	**0.17 B**	**0.792 A**	**4.70 A**	**31.7 A**	**49.1 A**
1 Shirati	0.53 b	0.15 b	0.803 a	4.60 a	31.7 a	51.7 a
2 Kinesi	0.82 ab	0.18 ab	0.782 a	4.83 a	31.7 a	45.9 a
Musoma	**1.00 A**	**0.27 A**	**0.738 A**	**5.05 A**	**34.7 A**	**44.3 A**
3 Musoma	0.91 ab	0.20 ab	0.758 a	5.00 a	38.4 a	55.5 a
4 Suguti	1.09 a	0.35 a	0.705 a	5.73 a	41.2 a	53.8 a
5 Majita	1.00 ab	0.26 ab	0.750 a	4.25 a	22.5 a	20.3 b
Bunda	**1.00 A**	**0.23 AB**	**0.822 A**	**5.68 A**	**37.3 A**	**48.8 A**
6 Kenkombyo	1.05 ab	0.30 ab	0.815 a	4.87 a	31.6 a	46.0 a
7 Nansimo	0.97 ab	0.18 ab	0.830 a	6.14 a	40.6 a	50.4 a

PEAs stationed in Bunda district had the longest in-service training compared to the other districts. Among the zones, Nansumo and Suguti zone had PEAs with the longest in-service training. The differences in in-service training among districts and zones were also similar in terms of the PEAs' length of project employment. The project had been active for the longest period of time (Table 7, last column) in Tarime district and Musoma zone as compared to the other two districts and six zones, respectively.

Johansson *et al*. [32] showed, in line with the above results, that the proportion of households ranking the PEAs knowledge in agroforestry as the best in the village had a positive effect on their decision to start planting trees but a negative effect on their decision to continue with agroforestry. This relationship was the reverse for the households' perception of the number of farmer-to-farmer tours conducted in their village. In the Suguti zone, a similar pattern appeared if independent variables used in Johansson *et al*. [32] (Appendix II) are plotted against the proportion of household testing agroforestry (with 1–30 surviving trees) compared to a plot against the proportion of households with a tangible commitment to agroforestry (with 40 or more surviving trees, Figure 7). The number of households with many surviving trees was more common in new villages compared to that in old villages, indicating that the duration of project activities in a village had a negative effect on the proportion of committed households. In contrast, an increasing number of training and awareness events, improved local collaboration, an increasing proportion of households believing in the ownership of trees and the good effect of agroforestry, all contributed to increase the proportion of households with many surviving trees in Suguti zone while the proportion of households with few surviving trees decreased (Figure 7).

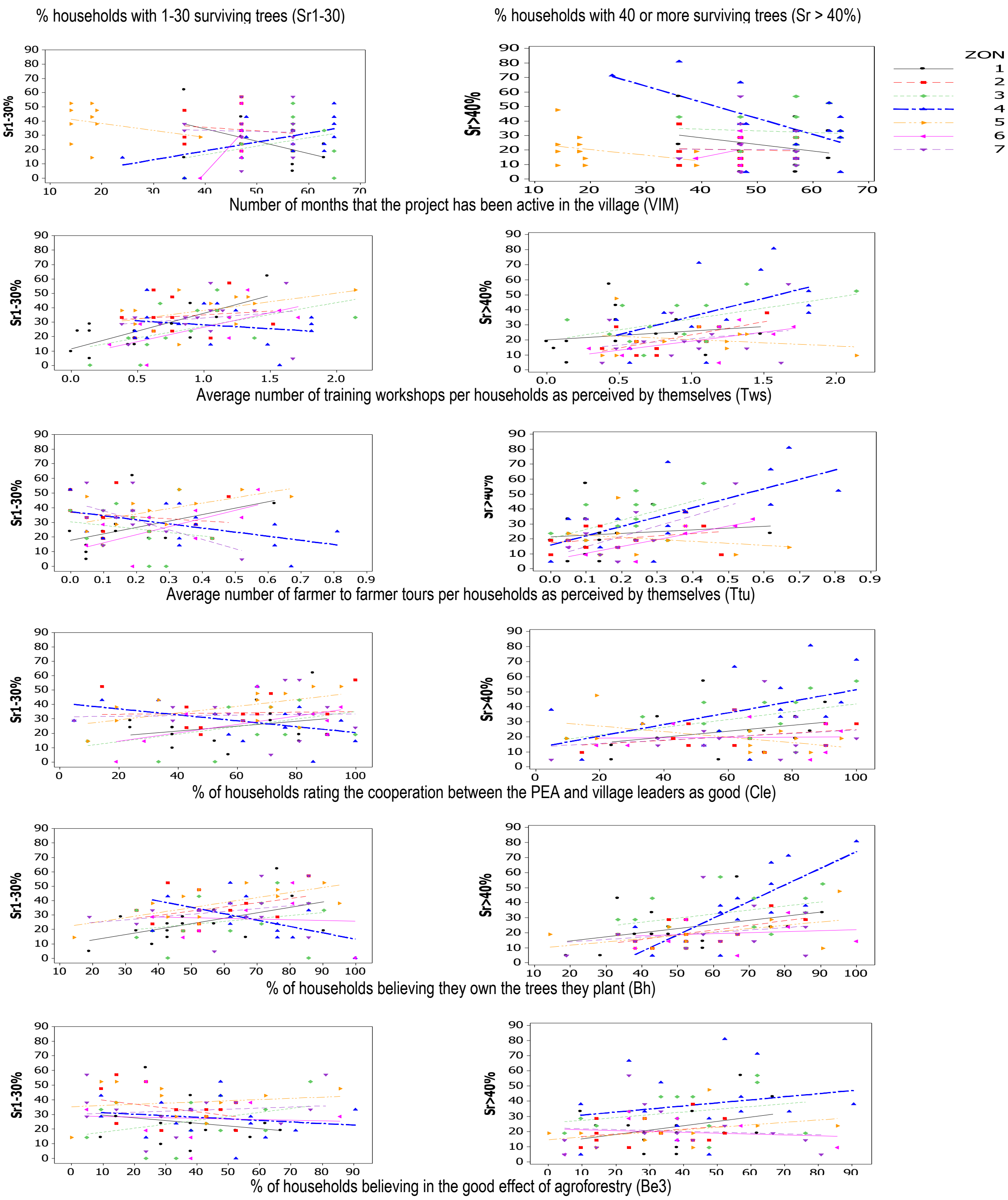
This suggest that these changes were not important or even negative to the households' decision to start planting trees while they were important for their decision to continue with tree planting and agroforestry. In the other zones, the influence of the five last effect variables in Figure 7 on the proportion of household with few and that of many trees were more similar showing a general positive effect. Hence, these five variables had a positive relationship on agroforestry development in general.

4.5. The Process of Learning, Adaption and Adoption: Synthesizing the Results

The results of this study suggest in line with earlier research [19,32] that the availability of information and training are important for farmers' decisions to start testing a new technology whereas socio-cultural issues becomes an additional challenge for a continuation beyond the testing phase leading to adoption of the technology [16–20]. This study also demonstrates the importance of governance and collaboration for the adoption process, the need to integrate project activities and capacity building into local structures to provide leverage in adaptation, adoption, and scaling up.

As the proportion of agroforestry households in the Suguti villages was comparatively high, above 65% on average (Table 4, first column), a larger proportion of these households was part of the agroforestry development progress as compared to the zones where the proportion of agroforestry households was smaller. Hence, an increase in the number of farmer-to-farmer tours in Suguti villages, and/or improved perception of tree ownership and local collaboration, increased the number of surviving trees mainly among households that already had agroforestry capacity and surviving trees, moving them from the proportion with few trees to that of many surviving trees. In the other zones with an average of less than 60% of households involved (Table 4, column two), the strength of this interaction was less pronounced (Figure 7). This suggests that the level of committed households in Suguti had reached a "tipping point" moving households from the proportion of testing households to the proportion of more committed households.

Figure 7. Scatter plots of independent variables against the proportion of households with some surviving agroforestry trees (Sr1–30) and the proportion of households with many surviving trees (Sr ≥ 40) showing a tipping-point in the Suguti zone (No. 4).



As the knowledge in agroforestry and the number of good examples were increasing in villages, like the villages in the Suguti zone, households had an increasing number of actors locally available for advice and with appropriate examples in agroforestry, besides the PEA and the project. Thus, the role of the PEA as the main advisor in agroforestry decreased in these villages. This explains why the proportion of households ranking their PEAs as very competent regarding agroforestry decreased with an increasing proportion of households with surviving trees (Figure 7 and Table 4 [32]). It further indicates a shift in the dissemination process itself, from being led by the project to a more self-driven process, in villages with many agroforestry farmers, many surviving trees and thus many good examples of agroforestry (Table 4).

As the proportion of household increased in a village beyond the pioneer farmers a growing number of the 80% food insecure households in the Mara lake zone [39] became involved. As the average number of trees and species per household increased, a growing number of households moved from just planting trees on miscellaneous land to integrating trees with other components of the subsistence system. With a growing proportion of households integrating an increasing number of trees on their farm, the number of farming practices, components and stakeholders affected and involved increased, e.g., support and production of staple crops, cash crops, livestock. Hence, the importance of streamlining and integrating farmers' training extension messages and adaptation with government extension and other organisations involved with the same households became increasingly critical.

The above results show, in line with Pollini [16], Ajayi *et al*. [19], and Johansson *et al*. [32], that the explanation to the contradictions similar to those found in this study often lies in the institutional and social-cultural contexts and requires a deeper understanding of the dynamics of the adoption processes of the respective study areas. In the decision to continue using a technology or not lies not only biophysical, technical and economic considerations, the prevailing socio-cultural contexts such as customs, obligations, beliefs and supportive governance are also important. These variations within the project area made the extension work demanding, involving effort beyond the PEA and the project to adapt and integrate interventions. A number of other studies (e.g., [11–20,29]) show how these complex challenges affect agroforestry dissemination and development.

At the beginning of the project, involvement of farmers and local stakeholders and agricultural extension was limited. It was technically trained extension workers disseminating "blueprint" interventions. In line with Long and Long [24], and Long [25], stressing the importance of interactions between people, technologies and institutions (organisations), from 1998 the emphasis of the PEAs' training was placed on building their capacity to actively involve households and local stakeholders in the adaptation, integration and dissemination process. Sanginga *et al*. [26], Sood and Mitchell [50] have stated that good collaboration improves coordination of the activities of different stakeholders streamlining extension, adaptive research and extension messages. Apart from collaboration at the village level, collaboration at the ward, district and division levels gradually became a central part of the project strategy and collaboration gradually improved at and between multiple levels (Table 2 and Figures 3–6).

In the pre-scaling up situation, important actors such as the politicians, executives and technical staff of different line ministries presented differing messages in relation to tree-ownership, seasonal planting of trees and the benefit of agroforestry (Figure 3). This situation changed considerably with time, particularly in the Musoma rural district; extension messages and in-service training of different stakeholders became increasingly synchronized (compare Figures 4–6). The conflicting messages about the effects of agroforestry trees on crops gradually converged. Integrated farmer-researcher designed experiments were critical in convincing households, agricultural extension services and even the project extension agents about the good effect of agroforestry. Agroforestry practices disseminated by the project and farm practices disseminated by the agricultural staff became increasingly compatible and integrated. With a growing involvement of the agricultural staff, agroforestry practices, tree establishment and management gradually became part of farmers' seasonal farm calendar and their perception of the same.

Collaboration with leaders and executives from a village to regional level were instrumental in helping farmers trust that they owned the trees they plant. The project could not have done this without their involvement in solving this critical barrier to adoption (Figure 3). The collaborative process reached in the Musoma rural district resembles Daniels and Walker's [27] concept of collaborative learning as an approach among stakeholders that makes them an integral part of the process, integrating and developing their knowledge and increasing the social capital. Collaboration at multiple levels was important in order to strengthen the local social capital to exchange knowledge and ideas, learn together and reach consensus in critical issues from household to regional levels and for all to converge in the same direction in the Mara region.

Mercer and Miller [17], Pattanayak *et al*. [18] and Mercer [29] discuss the importance of risk and uncertainty in agroforestry. Whereas, risk and uncertainty is widely recognized to be critical to adoption, it has rarely been considered in agroforestry. It is obvious that the long time from investment (nursery and planting) to experienced benefits (harvesting of wood and non-wood forest products) is an important aspect of agroforestry adoption; particularly for poor food-insecure farmers that have more urgent priorities than long term investments. The link between improved food production and agroforestry is not obvious and immediate enough to motivate the poor to invest in agroforestry.

A collaborative learning process contributes not only to understanding and handling of actual risks and benefits of agroforestry but also the farmers' perception of the same. It is also important that involved stakeholders understand development of collaboration as a stepwise learning process [51]. With all involved, the actual improvement farmers gain also becomes obvious to all and therefore mutually supported. Interventions that fail to pass the "test-criteria" of the farmers and other stakeholders will be exposed in due time before further dissemination, decreasing the risk of failure and backlashes. A growing proportion of households with experienced benefits of agroforestry, like in the Suguti zone, contribute to improve an initially negative local perception of risk in relation to agroforestry investment. Through the collaborative learning process, important simple and appropriate solutions were invented and developed decreasing the actual and perceived labour cost and risk.

One example is the use of a cassava fields to protect and harvest water for tree seedlings. As a crop of cassava stays considerably longer than other crops, seedlings planted in a cassava field are protected for a longer period compared to seedlings planted with other crops. Tree seedlings were planted in relation to tied ridges using the furrow for water harvesting. Timing and spacing of soil improvers in relation to different crops and weeding practices were also optimized in the collaborative process involving the perspectives of farmers as well as agricultural and agroforestry researchers and extension services. In this way, compatibility and synergies between the tree component and other components of the local subsistence systems gradually improved and became more evident to the farmers.

With an improved perception of risk and the benefits of trees, households gradually became incentivized to continue. Also, as the project actively promoted seasonal planting from the start of the year 2000, seasonal planting of agroforestry trees increased. Season after season of additional surviving trees will eventually lead to the possibility to also harvest trees seasonally.

The Suguti zone, located in the district with the highest level of established multi-level collaboration, had more than 65% of households involved in tree planting and agroforestry (Table 4, first column), the highest proportion of households believing in the positive effects of agroforestry (44%, Table 5) and the most households believing they owned the trees they plant (67%, Table 5). In turn, this improved their perception of the risks involved in tree planting and agroforestry. These results and the potential tipping point identified in the Suguti zone signifies that tree-establishment had become a more regular practice compared to other zones and that tree establishment was gradually moving into the domains of the seasonal farming calendar. An increasing number of farmers became a source of knowledge, evidence and promotion of agroforestry, showing how trees can be established and integrated with improving survival and benefit to the other components of the farming system. As a result, the importance of the PEA as a source of agroforestry knowledge and dissemination decreased.

5. Conclusions

The results of this study show that agroforestry adoption is knowledge intensive and complex. To train and motivate the pioneering households in a village to plant trees for a season or two can be accomplished through the effort of a project extension agent. However, to make the majority of households in a village adopt agroforestry practices requires involvement and efforts beyond the village level. It is necessary to develop increased levels of trust among farmers and other stakeholders representing different societal sectors and administrative levels to collaboratively adapt and integrate the improved practices into the local subsistence systems.

The take home lessons of this study are that:

(a) Scaling up of agroforestry is not a one man (project) show; it requires that households and the majority of stakeholders involved with them at multiple levels collaborate and are part of the process;
(b) Past or present government policies may work against the intervention and scaling up process;
(c) The local belief system and household perceptions may include obstacles towards engagement in agroforestry;
(d) When increased levels of trust and collaboration have been developed, stakeholders can collaboratively:

- Identify, consider and handle opportunities, barriers, conflicting approaches, messages, interests and perceptions.
- Lower and handle the actual and perceived risk in relation to investment in agroforestry.
- Develop and disseminate socially robust and ecologically sound and thus sustainable solutions that improve the existing subsistence systems.
- Identify and handle government policies and other non obvious obstacles that are incompatible with the proposed new practices.
- Make the process self driven and thus less independent from project activities and support.

The result of this study also shows that, apart from advancing agroforestry development, an inclusive multi-level collaborative approach, empowers the community, strengthen local people's rights and their capacity to improve their lives. Collaborative learning among stakeholders built on respect, equity and empowerment formed the basis for identifying barriers and developing solutions and was a critical success factor for the studied project. This wider approach to development resulted in improved resilience both of the local subsistence systems and the local socio-ecological system.

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Conflicts of Interest

The authors declare no conflict of interest.

Appendices

Appendix I. Dependent variables used in Johansson *et al*. [32].

Abbr.	Description of variable	Variable characteristics type	interval
Sr1–30	No of sample households with 1 to 30 agroforestry trees/soil-improvers (3 m soil-improvement hedge = 1 tree) surviving on their farm	discrete/interval	0–21
Sr ≥ 40	No of sample households with 40 or more agroforestry trees/soil-improvers (3 m soil-improvement hedge = 1 tree) surviving on their farm	discrete/interval	0–21
Sp ≥ 5	No of households with 5 or more surviving agroforestry-tree species of the species promoted by the project	discrete/interval	0–21
SrX	Average number of agroforestry-trees/soil-improvers surviving per sample household in a village, *i.e.*, the total number of surviving trees (3 m of soil improvement hedges = 1 tree) divided by all 21 sample household	continuous/interval	2.9–140.4
SrS	The accumulated total number of seasons from which the 21 sample household was found to have surviving agroforestry trees	continuous/interval	3–41

Appendix II. Factors and independent variables used in Johansson *et al*. [32].

Factor/variable	Description	Variable scale	Variable type	Method of analysis
i. The Institutional context				
DST	District: 1 Tarime, 2 Musoma rural, 3 Bunda	nominal	discrete 1–3	single anova
ZON	Project zone: 1 Shirati, 2 Kinesi, 3 Musoma, 4 Suguti, 5 Majita, 6 Kenkombyo, 7 Nansimo	nominal	discrete 1–29	single anova
VEHh	Level of cooperation between VEA & households according to project advisors & Zonal Managers; 1 = very poor 4 = good 2 = poor 5 = very good 3 = normal	ordinal scale	discrete 1–5	2-way anova
VEVL	Level of cooperation between VEA & village leadership to Project advisors & Zonal Managers; 1 = very poor 4 = good 2 = poor 5 = very good 3 = normal	ordinal scale	discrete 1–5	2-way anova
VLHh	Level of cooperation between village leadership & households according to Project advisors & Zonal Managers; 1 = very poor 4 = good 2 = poor 5 = very good 3 = normal	ordinal scale	discrete 1–5	2-way anova
Cle	The village proportion of households scoring the cooperation between village leaders and project extension agent to be good using three options: good normal poor	ratio scale	continuous 0–1	co-anova
Clh	The village proportion of households scoring the cooperation between village leaders and themselves to be good, using three options: good normal poor	ratio scale	continuous 0–1	co-anova
ii. The local belief system				
Bh	The village proportion of households believing they own the trees they plant.	ratio scale	continuous 0–1	co-anova
Be3	The village proportion of households believing in the good effect of agroforestry	ratio scale	continuous 0–1	co-anova
Ps	The village proportion of households ranking of PLANTING SEEDLINGS according to instructions among the three least demanding tasks out of 6 normal agricultural/AF-tasks - making crop ridges - making tied ridges - plant cassava - sow tree seed - sow maize	ratio scale	continuous 0–1	co-anova

Appendix II. *Cont.*

Factor/variable	Description	Variable scale	Variable type	Method of analysis
ii. The local belief system				
Ss	The village proportion of households ranking the task to SOW TREE SEED according to instructions among the three least demanding tasks out of 6 normal agricultural/AF-tasks: - making crop ridges - making tied ridges - plant cassava - planting tree seedling - sowing maize	ratio scale	continuous 0–1	co-anova
iii. The physical environment				
LAK	Mean distance from village middle to the Lake shore in km	ratio scale	discrete 1–8	2-way anova
MDW	Main source of domestic water: 1 = Lake only 0 = Other source	binary scale	discrete 0 or 1	2-way anova
MS	Main soil type of the village: 1 = Mbuga (clay rich soil) only and/or some Luseni 0 = Luseni (sandy soil) only and/or some Mbuga	binary scale	discrete 0 or 1	2-way anova
vi. The subsistence system				
MEA	Main Economic activity of the village: 1 = Agriculture only/agriculture mainly and some fishing 0 = Fishing mainly and some agriculture or fishing only	binary scale	discrete 0 or 1	2-way anova
MTM	Main tilling method used in the village: 1 = Ridging only or ridging mainly and some flat ox-ploughing 0 = Flat ox-ploughing mainly and some ridging or flat ox-ploughing only	binary scale	discrete 0 or 1	2-way anova
MC	Main Crop type: 1 = Cassava only 0 = Cassava and some other crop, *i.e.*, uCotton, Sorghum and/or Maize	binary scale	discrete 0 or 1	2-way anova
v. The project and the project extension agents				
Ttu	**Farmers tours**: Total No of farm-to farmers tours that the sample households have participated in as stated by the households themselves, divided by 21	ratio scale	continuous 0–1	co-anova
Tws	**Training workshop**: Total No of training workshop that the sample households have participated in as stated by the households themselves, divided by 21	ratio scale	continuous 0–3	co-anova
VIM	**Vi AFP-months**—No of months that the project have been active in the village	ratio scale	approximately continues 14–65	co-anova

Appendix II. *Cont.*

Factor/variable	Description	Variable scale	Variable type	Method of analysis
v. The project and the project extension agents				
SEX	Gender of the project extension agent in the village: 1 = female 0 = male	binary scale	discrete 0 or 1	2-way anova
VEIS	In-service training; number of weeks of in-service training that the project extension agent has participated in	ratio scale	discrete 3–8	2-way anova
VEM	Number of months that the project extension agent has been employed by the project	ratio scale	approximately discrete 3–75	co-anova
VEHL	Mother tongue of the project extension agent in relation to the main language in her/his village: 1 = the same language 0 = not the same language	binary	discrete 1 or 0	2-way anova
VELE	Duration/level of education of the project extension agent: 1 = 3 years certificate, 2 years diploma or 3–4 years BSc 0 = Work experience and no education or up to 2 years certificate education	binary scale	discrete 0 or 1	2-way anova
VEDE	Education discipline of the project extension agent: 1 = Education related to agriculture, livestock prod, forestry, and/or land-use 0 = Community development, veterinary/animal health and/or education/teacher	binary scale	discrete 0 or 1	2-way anova
Kef	The village proportion of households ranking the project extension agent as number one in agroforestry knowledge among seven other key actors in the village; - agricultural extension agent - village executive officer - village chairman - Hh interviewee (ideally household head) - wife or husband of interviewee/household head - son in the Hh - daughter in the Hh	ratio scale	continuous 0–1	co-anova
Def	The village proportion of households ranking the project extension agent as number one in devotion to agroforestry among five other key actors in the village: - agricultural extension agent - village executive officer - village chairman - sub-village leader - active agroforestry farmer	ratio scale	continuous 0–1	co-anova

Appendix III

Figure A1. Scatter plot of the village proportion of households believing they own the trees they plant (Bh) against the proportion of households with 40 or more surviving agroforestry trees (Sr ≥ 40), the proportion of households with five or more surviving agroforestry species (Sp ≥ 5), the average number of surviving agroforestry trees per household (SrX) and the accumulated total number of seasons from which the sample household was found to have surviving agroforestry trees (SrS) using the administrative district or project zone as the categorical factor.

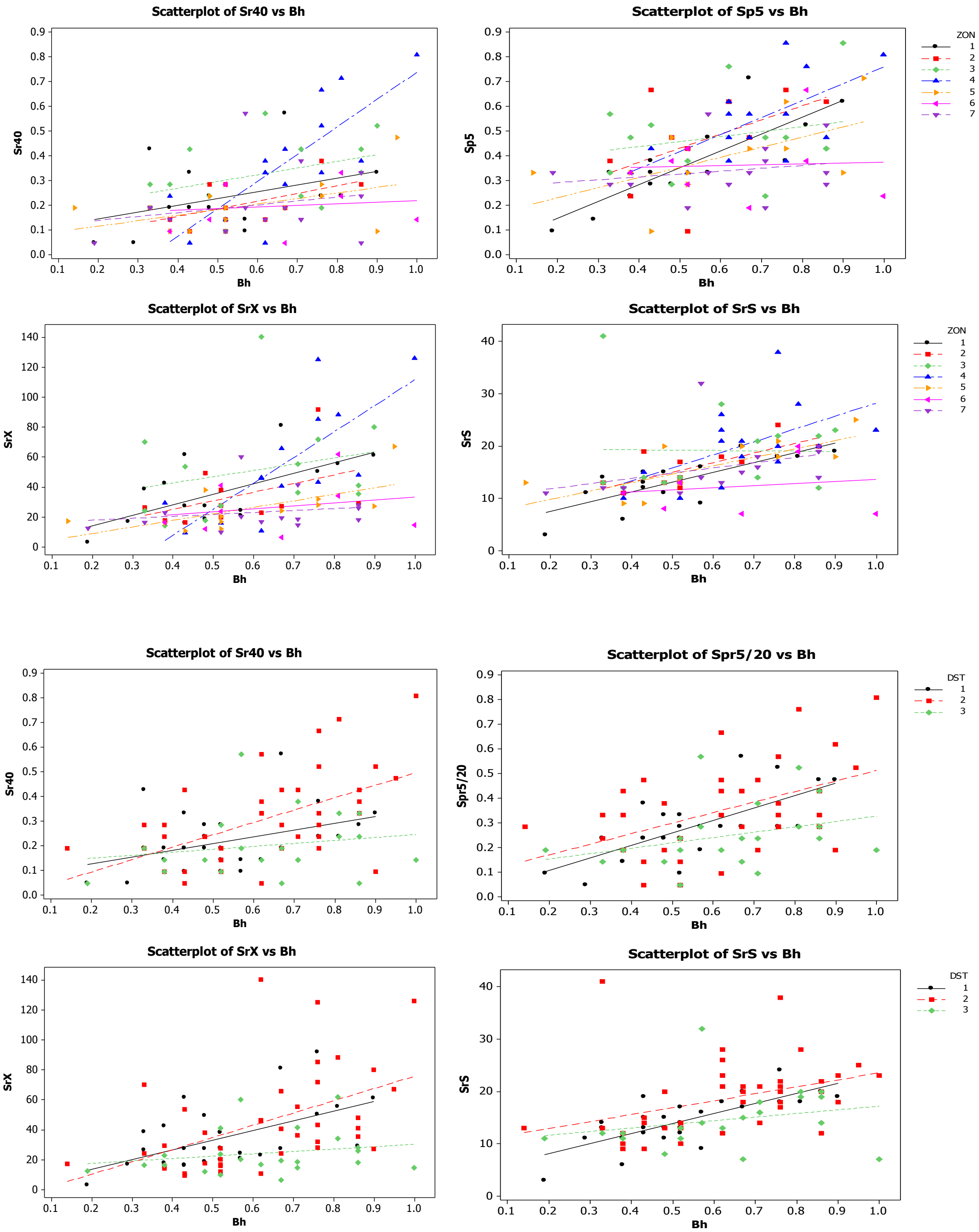
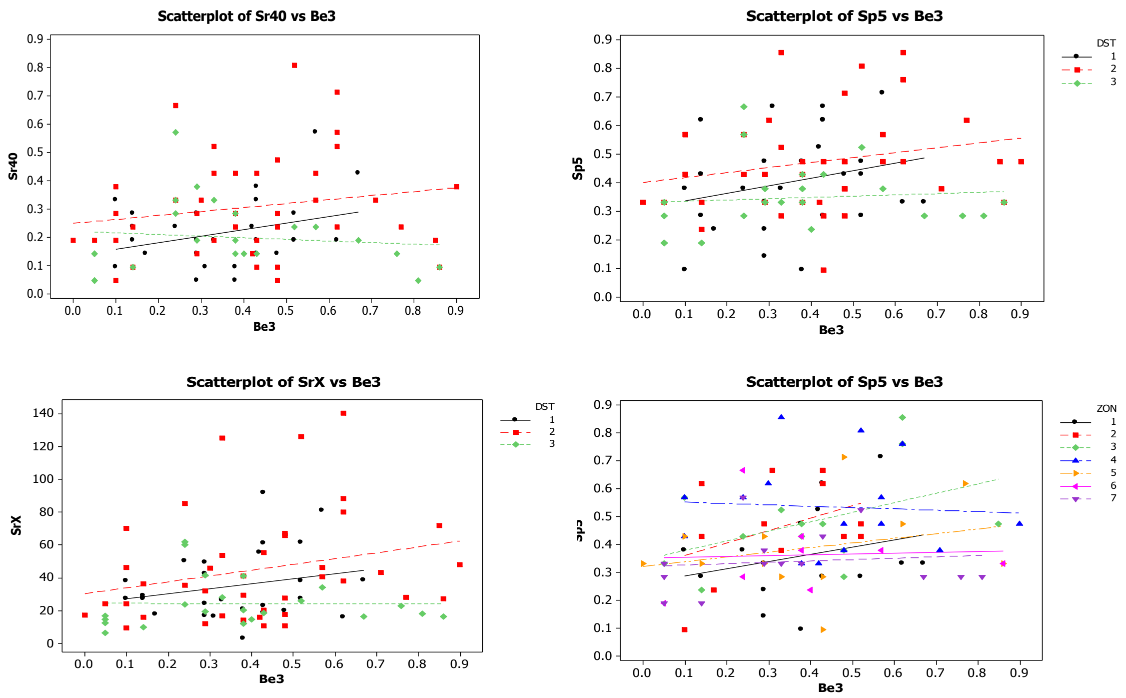


Figure A2. Scatter plot of the village proportion of households believing in the good effect of agroforestry (Be3) against the proportion of households with 40 or more surviving agroforestry trees (Sr ≥ 40), the proportion of households with five or more surviving agroforestry species (Sp ≥ 5) and the average number of surviving agroforestry trees per household (SrX) using the administrative district or project zone as the categorical factor.



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